Center Independent Research & Development: GSFC IRAD

Optical Clock Technology for Coherent Optimetrics and Time Frequency Transfer

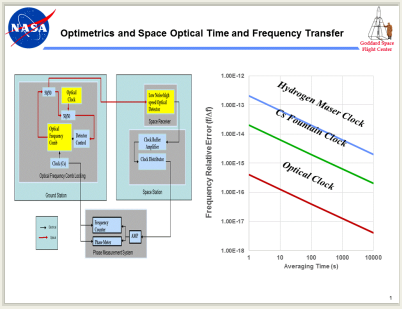
Completed Technology Project (2017 - 2018)

Project Introduction

We propose to perform a study and experimental demonstration of Optical Clock Technology for enhanced Coherent Optimetrics, and ultra-high precision time and frequency transfer. In coherent optimetrics configuration, the system will be locked to an Optical Clock to demonstrate **nm** range and ranging rate performance. In time and frequency transfer mode, an optical frequency comb will be lock the Optical Clock to demonstrate an unprecedented precision time and frequency transfer to remote satellite (such as TDRS). It makes precision time and clock available on any satellite without having to carry bulky optical clock source on board. This dual technology, **coherent optimetrics** and **precision optical clock time frequency transfer** will greatly advance the state of art on ranging, clock and timing in space. Greatly benefit both Gravitational [3] and Planetary [4] sciences. This technology development is leveraging the vast technology progress in the fields: **a.** High speed coherent optical communication (Telecomm) (>100GBPS) with photonic integrated circuit (PIC) and high speed analog and digital electronics . **b.** Low noise laser source and optical clock development from both gravity wave measurement (LISA) and optical clock research. **c.** optical frequency comb development for high precision metrology, spectroscopy, etc . This proposal also leverages last couple of years' project "High Precision RF Ranging and Range Rate Measurements over Optical Carrier and Laser Communication in Cubesat Platform", and "Coherent Optimetric Measurements and Optical Communication". The success of this study will provide platform with both ranging over continuous optical phase (~nm error) and high precision optical frequency transfer (relative frequency error of 10^{-17}). It will be game changing technology with such high precision ranging and high bandwidth communication. It will service both science and NAV/COMM at a new level of ranging precision and comm capacity. It will also advance the state-of-the-art for the optical comm system with high bandwidth and high precision ranging. It will be an enabler for precision formation flying missions that include: virtual sensors, sensor webs, large-number-multi-spacecraft distributed mission, autonomous rendezvous & docking; and enabler for gravitational based small-sat scientific missions.

Anticipated Benefits

Time and frequency accuracies represent both a fundamental limiter and enabler for many scientific measurements. Infusion of the NIST developed optical clock technology into NASA optical communication systems would provide 3 orders of magnitude improvement over current microwave technology. Such significant a leap of accuracy, combined with coherent optimetrics, and coherent optical communication, will enable new science instrumentation and other instrumentation accuracies will be dramatically improved, including, but not limited:



Optimetrics and Space Optical Time and Frequency Transfer

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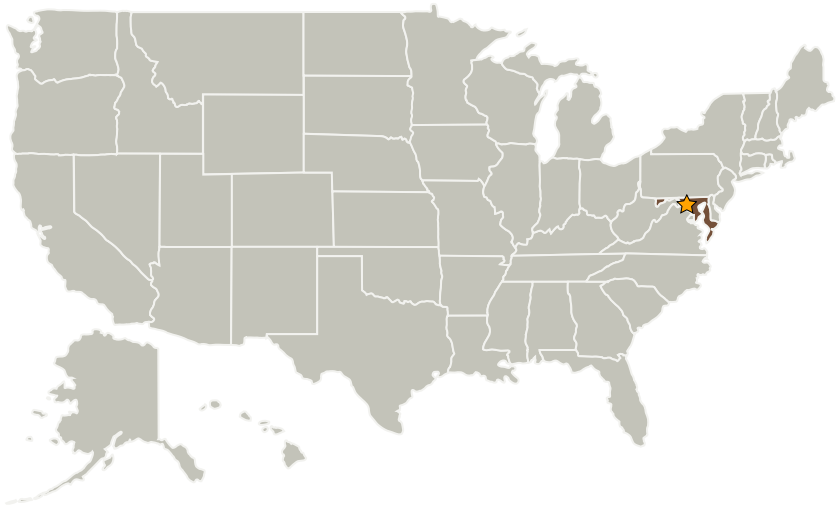
1. Establish a new high accuracy time and frequency transfer service which would enable many other game changing applications similar to the onset of GNSS/GPS services
2. Planetary science of very long baseline geodesy measurement
3. Earth and planetary sciences of gravimetric measurements from space
4. Enabling advances in high precision sensor webs and constellations and autonomous rendezvous & docking

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Managers:

Terry Doiron
Timothy D Beach
Jason M Mitchell
Lavida D Cooper

Principal Investigator:

Guangning Yang

Co-Investigator:

Gregory W Heckler

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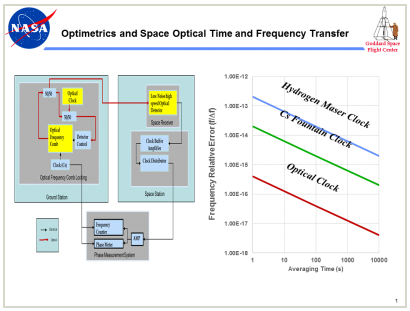
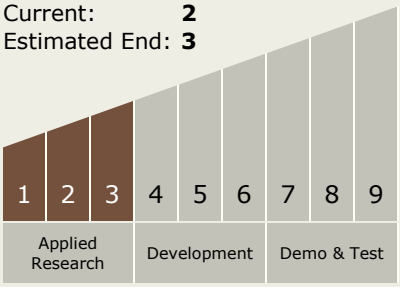
Images



Optimetrics and Space Optical Time and Frequency Transfer
Optimetrics and Space Optical Time and Frequency Transfer *(https://techport.nasa.gov/image/32102)*

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.1 Optical Communications
    - TX05.1.6 Optimetrics

Target Destinations

Earth, Mars

Supported Mission Type

Projected Mission (Pull)